UNIVERSITY OF SOUTH CAROLINA

Independent Verification and Validation Process

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IV&V Project Manager

Agenda

- Definition of Verification and Validation
- Overview of Formal V&V
- Federal Requirements for IV&V
- IV&V Process for the South Carolina Child Support Enforcement Development Effort
- Question and Answer Period

Definition of Verification and Validation

Verification and Validation

- A systems engineering discipline to assist in building quality into the software
  - Validation
    - Ensuring that the software meets the users' needs
    - *"Are we building the right system?"*
  - Verification
    - Ensuring that the system is well engineered
    - *"Are we building the system right?"*

PMBOK Definition of **Quality**

- The degree to which a set of inherent characteristics fulfills *requirements*.

Similarities Do Exist

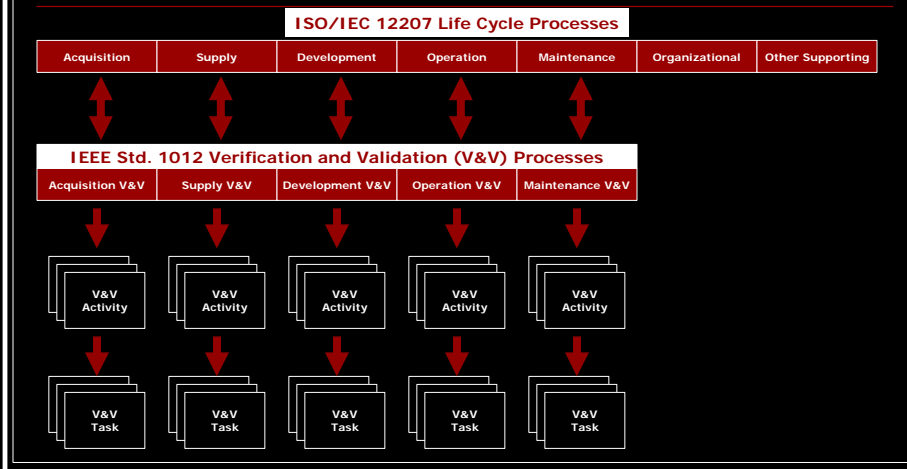Quality - The degree to which a set of inherent characteristics fulfills *requirements*.

- Validation - Ensuring that the software meets the users' needs.

- Verification - Ensuring that the system is well engineered.

Overview of Formal V&V

IEEE Std. 1012-2004

- *IEEE Standard for Software Verification and Validation*
- Includes the *"processes to determine whether the development products of a given activity conform to the requirements of that activity and whether the software satisfies its intended use and user needs."*

V&V Processes, Activities, and Tasks

ISO/IEC 12207 Life Cycle Processes						
Acquisition	Supply	Development	Operation	Maintenance	Organizational	Other Supporting

IEEE Std. 1012 Verification and Validation (V&V) Processes				
Acquisition V&V	Supply V&V	Development V&V	Operation V&V	Maintenance V&V

V&V Activity	V&V Activity	V&V Activity	V&V Activity	V&V Activity

V&V Task	V&V Task	V&V Task	V&V Task	V&V Task

Process: Development

- Activity: Concept V&V
- Activity: Requirements V&V
- Activity: Design V&V
- Activity: Implementation V&V
- Activity: Test V&V
- Activity: Installation and Checkout V&V

Activity: Requirements V&V

- Task: Traceability Analysis
- Task: Software Requirements Evaluation
- Task: Interface Analysis
- Task: Criticality Analysis
- Task: System V&V Test Plan Generation
- Task: Acceptance V&V Test Plan Generation
- Task: Configuration Management Assessment
- Task: Hazard Analysis
- Task: Security Analysis
- Task: Risk Analysis

5.4.2 Activity: Requirements V&V (Process: Development)		
V&V tasks	**Required inputs**	**Required outputs**

(1) Traceability analysis
 	
Trace the software requirements (SRS and IRS) to system requirements (concept documentation) and system requirements to the software requirements.
 	
Analyze identified relationships for correctness, consistency, completeness, and accuracy. The task criteria are
a) Correctness
  Validate that the relationships between each software requirement and its system requirement are correct.
b) Consistency
  Verify that the relationships between the software and system requirements are specified to a consistent level of detail.
c) Completeness
  1) Verify that every software requirement is traceable to a system requirement with sufficient detail to show conformance to the system requirement.
  2) Verify that all system requirements related to software are traceable to software requirements.
d) Accuracy
  Validate that the system performance and operating characteristics are accurately specified by the traced software requirements.
	Concept documentation (system requirements)
	
	SRS
	
	IRS
		Task Report(s)—Traceability analysis
		
		Anomaly report(s)

(2) Software requirements evaluation Evaluate the requirements (e.g. functional capability, interface	Concept documentation	Task report(s)—Software requirements

	formance to the system requirement. 2) Verify that all system requirements related to software are traceable to software requirements. d) Accuracy Validate that the system performance and operating characteristics are accurately specified by the traced software requirements.		

	(2) Software requirements evaluation
	
	Evaluate the requirements (e.g., functional, capability, interface, qualification, safety, security, human factors, data definitions, user documentation, installation and acceptance, user operation, and user maintenance) of the SRS and IRS for correctness, consistency, completeness, accuracy, readability, and testability. The task criteria are
	a) Correctness
	   1) Verify and validate that the software requirements satisfy the system requirements allocated to software within the assumptions, constraints, and operating environment for the system.
	   2) Verify that the software requirements comply with standards, references, regulations, policies, physical laws, and business rules.
	   3) Validate the sequences of states and state changes using logic and data flows coupled with domain expertise, prototyping results, engineering principles, or other basis.
	   4) Validate that the flow of data and control satisfy functionality and performance requirements.
	   5) Validate data usage and format.
		Concept documentation
		
		SRS
		
		IRS
			Task report(s)—
			Software requirements evaluation
			
			Anomaly report(s)

(2) Software requirements evaluation *(continued)*

b) Consistency
   1) Verify that all terms and concepts are documented consistently.
   2) Verify that the function interactions and assumptions are consistent and satisfy system requirements and acquisition needs.
   3) Verify that there is internal consistency between the software requirements and external consistency with the system requirements.

c) Completeness
   1) Verify that the following elements are in the SRS or IRS, within the assumptions and constraints of the system:
      i) Functionality (e.g., algorithms, state/mode definitions, input/output validation, exception handling, reporting and logging)
      ii) Process definition and scheduling
      iii) Hardware, software, and user interface descriptions
      iv) Performance criteria (e.g., timing, sizing, speed, capacity, accuracy, precision, safety, and security)
      v) Critical configuration data
      vi) System, device, and software control (e.g., initialization, transaction and state monitoring, self-testing)
   2) Verify that the SRS and IRS satisfy specified configuration management procedures.

d) Accuracy
   1) Validate that the logic, computational, and interface precision (e.g., truncation and rounding) satisfy the

IRS, within the assumptions and constraints of the system:

   i) Functionality (e.g., algorithms, state/mode definitions, input/output validation, exception handling, reporting and logging)

   ii) Process definition and scheduling

   iii) Hardware, software, and user interface descriptions

   iv) Performance criteria (e.g., timing, sizing, speed, capacity, accuracy, precision, safety, and security)

   v) Critical configuration data

   vi) System, device, and software control (e.g., initialization, transaction and state monitoring, self-testing)

  2) Verify that the SRS and IRS satisfy specified configuration management procedures.

d) Accuracy

  1) Validate that the logic, computational, and interface precision (e.g., truncation and rounding) satisfy the requirements in the system environment.

  2) Validate that the modeled physical phenomena conform to system accuracy requirements and physical laws.

e) Readability

  1) Verify that the documentation is legible, understandable, and unambiguous to the intended audience.

  2) Verify that the documentation defines all acronyms, mnemonics, abbreviations, terms, and symbols.

f) Testability

Verify that there are objective acceptance criteria for validating the requirements of the SRS and IRS.

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(3) Interface analysis Verify and validate that the requirements for software interfaces with hardware, user, operator, and other systems are correct, consistent, complete, accurate, and testable. The task criteria are a) Correctness Validate the external and internal system and software interface requirements. b) Consistency Verify that the interface descriptions are consistent between the SRS and IRS. c) Completeness Verify that each interface is described and includes data format and performance criteria (e.g., timing, bandwidth, accuracy, safety, and security). d) Accuracy Verify that each interface provides information with the required accuracy. e) Testability Verify that there are objective acceptance criteria for validating the interface requirements.	Concept documentation IRS	Task report(s)—Interface analysis Anomaly report(s)
(4) Criticality analysis a) Review and update the existing criticality analysis results from the prior criticality task report using the SRS and IRS. b) Implementation methods and interfacing technologies may cause previously assigned software integrity levels to be raised or lowered for a given software element (i.e., requirement, module, function, subsystem, other software partition). Verify that no inconsistent or undesired software integrity consequences are introduced by reviewing the revised software integrity levels.	Criticality task report SRS IRS	Task report(s)—Criticality analysis Anomaly report(s)

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Software Integrity Levels

- Integrity Level 4
  - Software element must execute correctly or grave consequences *(loss of life, loss of system, economic or social loss)* will occur. No mitigation is possible.
- Integrity Level 3
  - Software element must execute correctly or the intended use *(mission)* of the system/software will not be realized, causing serious consequences *(permanent injury, major system degradation, economic or social impact)*. Partial to complete mitigation is possible.
- Integrity Level 2
  - Software element must execute correctly or an intended function will not be realized, causing minor consequences. Complete mitigation is possible.
- Integrity Level 1
  - Software element must execute correctly or intended function will not be realized, causing negligible consequences. Mitigation not required.

Scope of V&V

- Largely dependent upon the size, complexity, and criticality of the project
- Many major components with Integrity Levels 3 and 4 increase the V&V scope

Table 2—Minimum V&V tasks assigned to each softwa...

Life cycle processes	Process: Acquisition (see 5.2)				Process: Supply (see 5.3)																Pro Develo (see
V&V activities	Activity: Acquisition support V&V (see 5.2.1)				Activity: Planning V&V (see 5.3.1)				Activity: Concept V&V (see 5.4.1)				Activity: Require-ments V&V (see 5.4.2)				Activity: Design V&V (see 5.4.3)			
Software integrity levels	Levels				Levels				Levels				Levels				Levels			
	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1
Integration V&V test case generation																				
Integration V&V test design generation																	X	X	X	X
Integration V&V test execution																				
Integration V&V test plan generation																	X	X	X	X
Integration V&V test procedure generation																				
Interface analysis													X	X	X		X	X	X	
Interface with organizational and supporting processes	X	X			X	X			X	X			X	X			X	X		
Management and technical review support	X	X			X	X			X	X			X	X			X	X		
Management review of the V&V effort	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Migration assessment																				
New constraints evaluation																				
Operating procedures evaluation																				

Independence Parameters

- Technical Independence
- Managerial Independence
- Financial Independence

Technical Independence

- Utilizes personnel who are not involved in the development of the software
- *"Fresh viewpoint"* valuable in detecting subtle errors overlooked by those too close to the solution
- The IV&V effort uses or develops its own set of analysis and test tools separate from the developer's tools

Managerial Independence

- Responsibility for the IV&V effort be vested in an organization separate from the development and program management organizations
- IV&V selects the things to be analyzed and tested, defines the schedule for its activities, and selects the specific technical issues and problems upon which to act

Financial Independence

- Control of the IV&V budget is vested in an organization independent of the development organization
- Prevents situations where the IV&V effort cannot be completed because funds have been diverted or adverse financial pressures or influences have been exerted

Forms of Independence

- Classical Independence
- Modified Independence
- Integrated Independence
- Internal Independence
- Embedded Independence

Classical Independence

- Embodies all three independence parameters
    - Responsibility vested in a separate organization
    - Close working relationship to ensure that findings are integrated rapidly into the development process
    - Generally required for projects where loss of life, loss of mission, or significant social or financial loss is likely

Modified Independence

- Used in many large programs where everything is the responsibility of the prime contractor
- Managerial independence is compromised
- Uses separate staff and a separate budget

Integrated Independence

- Focused upon rapid feedback into the development process
- Financially and managerially independent, but technical independence is compromised
- IV&V works side-by-side with the development team providing immediate feedback and consultation

Internal Independence

- The developer conducts IV&V with its own personnel *(preferably not those directly involved in development)*
- All independence parameters are compromised
- Used when benefits of pre-existing staff knowledge outweigh the benefits of objectivity

Embedded Independence

- Similar to internal IV&V in that personnel from the development organization
- Work side-by-side with the developers
- Not tasked specifically to independently assess the original solution or conduct independent tests

Degrees of IV&V Independence

IV&V Form	Technical	Management	Financial
Classical	R	R	R
Modified	R	C	R
Integrated	C	R	R
Internal	C	C	C
Embedded	M	M	M
R = Rigorous; C = Conditional; M = Minimal			

Quality Assurance Planning

- Often includes Verification and Validation Planning
- Planning V&V processes, activities, and tasks to be used to determine if the deliverables conform to the requirements
- Determining degree of independence needed to attain this level of assurance
- Depending upon source of the QA function, may be performed internally

Federal Requirements for IV&V

Federal Mandate for IV&V

- IV&V required for Federally subsidized system automation projects
- Comprehensive assessment of the project processes and deliverables
- Concurrent reporting to State and Federal stakeholders
- Classical independence required
- Loose conformance to IEEE 1012

Activity: Requirements V&V

- Task: Traceability Analysis
- Task: Software Requirements Evaluation
- Task: Interface Analysis
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- Task: System V&V Test Plan Generation
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- Task: Hazard Analysis
- Task: Security Analysis
- Task: Risk Analysis

Assessment Variations

- Periodic Assessment
  - Comprehensive assessment performed every six months with a follow up report
- Ongoing IV&V Presence
  - Full-time involvement in an oversight role *(non-consultative)* with comprehensive quarterly assessments

Federal IV&V Triggers

Criteria from CFR 307.15(b)(10) that trigger an IV&V assessment of a State system

(A) State does not have in place a statewide automated child support enforcement system that meets the requirements of the FSA of 1988

(B) States which fail to meet a critical milestone, as identified in their APDs

(C) States which fail to timely and completely submit APD updates

(D) States whose APD indicates the need for a total system redesign

(E) States developing systems under waivers pursuant to section 452(d)(3) of the Social Security Act

(F) States whose system development efforts we determine are at risk of failure, significant delay, or significant cost overrun.

Federal Independence Requirements

- Contract with an independent company capable of providing the services
- Establish an inter-agency agreement with another State agency
  - Cannot be under the same agency that is developing the system
  - Must meet Federal requirements for performing the IV&V services

SC CSES
IV&V Process

How is IV&V performed?

- Confirmation by examination and objective evidence through:
  - Ensuring the existence, adequacy, and accuracy of processes and plans
  - Ensuring adherence to processes and plans
  - Attendance in meetings and project reviews
  - Interviews and other stakeholder contacts
  - Review of documentation and reports
- Adequacy, accuracy, and adherence measured against standards and best practices

IV&V Reporting

- Regular Reports
  - Quarterly Report *(QR)*
    - Comprehensive Quarterly Assessment
    - End of each calendar quarter
  - Quarterly Report Update *(QRU)*
    - Interim progress on findings
    - Approximately six weeks into a new quarter
- Reported concurrently to State and Federal stakeholders

Maintaining Independence
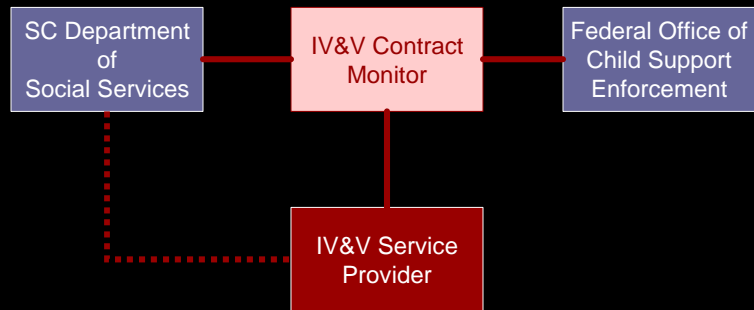
General IV&V Process
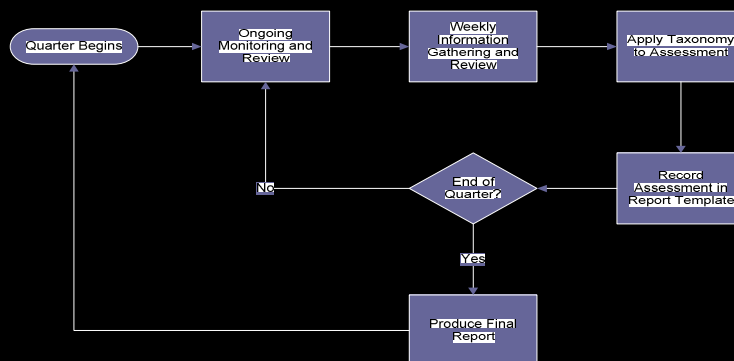
Statement of Work Tasks

	Task Area	Number of Tasks
1	Project Management	25
2	Quality Management	8
3	Requirements Management	17
4	Operating Environment	14
5	Development Environment	15
6	Software Development	22
7	System and Acceptance Testing	13
8	Data Management	8
9	Training	9
10	Operations Oversight	6

Project Management Task Area
- *Subarea Breakdown*

- Project Sponsorship (1)
- Management Assessment (3)
- Project Management (4)
- Business Process Reengineering (3)
- Risk Management (1)
- Change Management (1)
- Communications Management (1)
- Project Estimating and Scheduling (3)
- Project Personnel (2)
- Project Organization (1)
- Subcontractors and External Staff (2)
- State Management Oversight (3)

Taxonomy-Based Assessment

- Primary Responsibility Areas by SOW Tasks
- Use Taxonomy to Perform Comprehensive, Quarterly Assessment
- Record Assessment Conclusions in the Quarterly Report

Sample SOW Task Assessment

- **PM-5**: Verify that an appropriate project management plan has been documented. Assess whether the plan is consistently communicated, implemented, and monitored. Evaluate the effectiveness of the project management plan.

| Project Management	
PM-5	**Verify that an appropriate project management plan has been documented. Assess whether the plan is consistently communicated, implemented, and monitored. Evaluate the effectiveness of the project management plan.**
PM-5.1	**Does a project management plan exist and does it document how the project is to be executed, monitored and controlled, and closed?**
References	*A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 4.3, page 88*
Guidance	*The expectation is that the project team will produce and manage the overall project management plan and the development contractor will be responsible for its development management plan. The two plans should be complementary with the development contractor's plan being a subsidiary document for the overall project management plan.*
PM-5.2	**Is the project management plan sufficiently detailed or does it identify the appropriate subsidiary plan where the details are to be provided?**
References	*A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 4.3, page 88* *IEEE STD 1058-1998 - IEEE Standard for Software Project Management Plans; Section 4.2, page 6*
Guidance	*The PMBOK reference relates to the overall project management plan and IEEE reference to the development contractor's management plan.* *The PMBOK defines a project management plan as: "A formal, approved document that defines how the project is executed, monitored and controlled. It may be summary or detailed and may be composed of one or more subsidiary management plans and other planning documents." IV&V will expect that where subsidiary plans and processes are used to detail plans and processes, the project management plan will still include a summary of how the project is to be executed, monitored and controlled.* *In short, the reader should be able to get a comprehensive view of the overall project from the project management plan without having to reference any subsidiary plans and processes. Subsidiary documents should only need to be referenced when details not included in the management plan itself need to be understood by the reader. Where the details are simple, IV&V would prefer that they be included in the project management plan rather than in a separate document.*

PM-5.4	**Does the project management plan include all of the expected components, such as the scope management plan, schedule management plan, cost management plan, process improvement plan, staffing management plan, communication management plan, risk management plan, procurement management plan, milestone list, schedule baseline, cost baseline, quality baseline, risk register, project charter, scope statement, work breakdown structure (WBS), responsibility assignments, schedules, key staffing requirements, budgets, performance measurement baselines, lists of key risks, risk response plans, management review plans, project execution plan, and other subsidiary management plans?**	
References	*A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 4.3, page 89* *Project Manager Competency Development (PMCD) Framework; Performance Criteria 6, Page 15* *IEEE STD 1058-1998 - IEEE Standard for Software Project Management Plans*	
Guidance	*This question relates primarily to the overall project management plan. Based upon the approach used by the PMO, not all of these components may be essential. Because the development contractor's plan will largely be used to manage the development effort to the contract, the details are less important. The IEEE standard may be referenced to determine what elements are most critical for the development contractor's plan.*	
PM-5.5	**Does the project management plan identify and define the project management processes to be used?**	
References	*A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 4.3, page 88*	
Guidance	*This question is applicable to both the overall project management plan and development contractor's management plan, but the processes to be used will vary considerably. The PMO will be expected to identify formal project management processes for the formal management of the overall project, while the development contractor will likely name processes to control the system development effort.*	
PM-5.6	**Does the project management plan describe the tools and techniques to be used for accomplishing the project management processes?**	
References	*A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 4.3, page 88*	
Guidance	*This question is applicable to both the overall project management plan and development contractor's management plan. Simply listing the tools will not be sufficient. There must be a*	

PM-5.9	Does the project management plan identify the selected project life cycle and for multi-phase projects identify the specific project phases?
References	A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Chapter 2 and Section 4.3, page 88
Guidance	For purposes of the CFS project this relates to individual life cycles for CSES, FCCMS, and SDU and the interrelationship of those life cycles for the overall project.
PM-5.10	Does the project management plan define how work will be authorized and how project deliverables will be approved?
References	Project Manager Competency Development (PMCD) Framework; Performance Criteria 9, Page 16
Guidance	The project management plan should at least summarize the means by which work is authorized and deliverables are approved, even if the details are in a subsidiary plan and/or process.
PM-5.11	Is the project managed according to the integrated set of processes identified in the project management plan and subordinate plans?
References	A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 4.3, page 88
Guidance	This implies that there is an integrated set of processes in the plans, as should have been determined by PM-5.1 and PM 5.2. The essence of this question is whether the plans and processes are being consistently used by the project team.
PM-5.12	Does the project management plan include generic plan information on the methods for updating, reviewing, and disseminating the project management plan?
References	IEEE STD 1058-1998 - IEEE Standard for Software Project Management Plans; Section 4.1.2, page 5
Guidance	Though the reference relates to the software project management plan, the question is applicable to both the development contractor and the PMO. There should be a systematic approach to updating the plan.
PM-5.13	Does a project scope management plan exist and does it provide guidance on how project scope will be defined, documented, verified, managed, and controlled?
References	A Guide to the Project Management Body of Knowledge (PMBOK Guide: 2004 Edition); Section 5.1.3.1, page 108

Assessment Conclusions

- The report should contain the current status of SCDSS's project effort, including any pertinent historical background information.
- The detailed analysis of each task should also answer the following questions:
  - Are appropriate plans and processes defined?
  - Are these plans and processes being followed consistently?
  - Are the plans and processes effective? *(This should include what is good about the plans and processes, as well as what is not.)*
  - In what ways might the process or technology be improved?
  - Where is measurable progress being made in this area?
  - Is the effort within scope, budget, and schedule constraints?
  - What standards are being following?
  - Is the appropriate documentation accurate and up-to-date?
- The responses in the comprehensive analysis should be quantified, whenever possible.

General IV&V Process
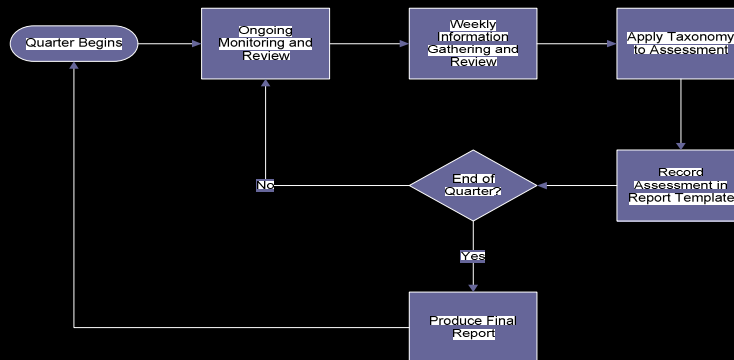
IV&V Findings

- Where the assessment identifies areas of significant risk and/or concern, an IV&V finding is created.
- Priorities are assigned by OCSE
- Elevates the concern to the State and Federal stakeholders for their attention
- Progress toward closure of each finding is reported in the Quarterly Report and interim updates

Composition of a Finding

- Unique Identifier
- Brief Description
- Period Opened/Closed
- Priority *(based upon Degree of Impact, Probability of Impact, and Time Criticality)*
- One or more Finding Elements
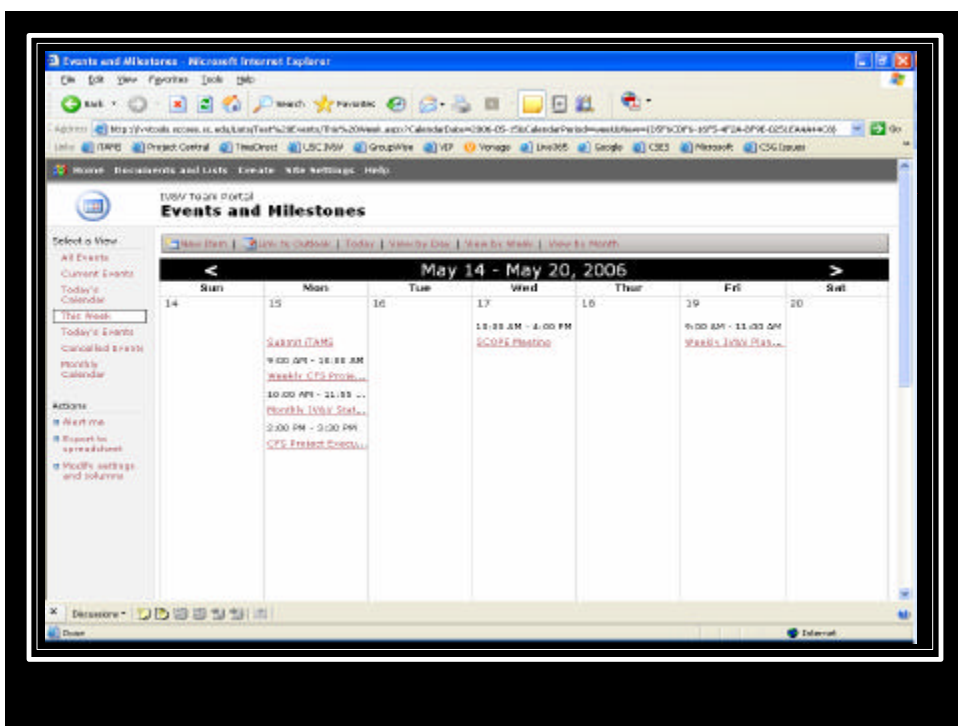
Composition of a Finding Element

- Unique Identifier
- Period Opened/Closed
- Progress Indicator *(e.g. No Progress Observed)*
- Linkage to SOW Task Assessments
- Description
- Justification
- Recommendation
- Relevant Standards, Best Practices, and Related Resources
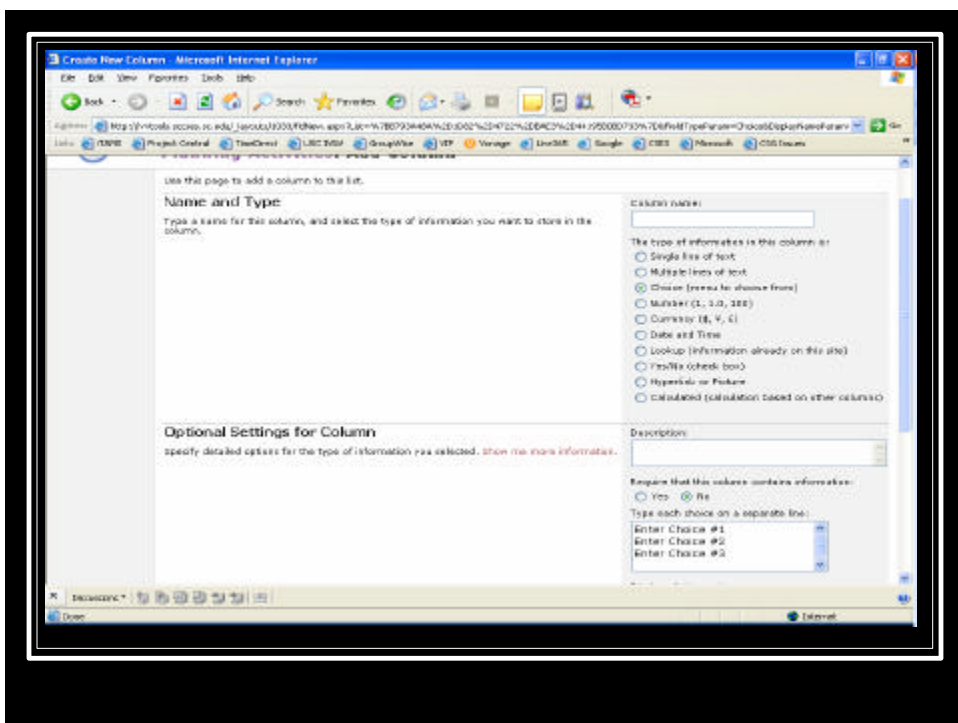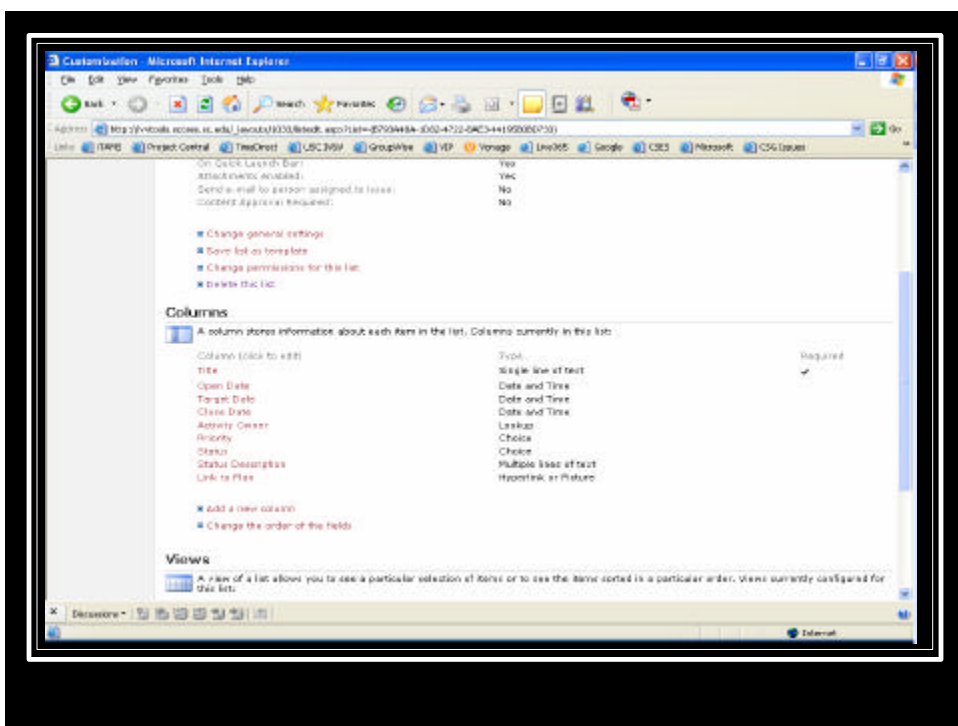- Progress Description
- Resolution

General IV&V Process
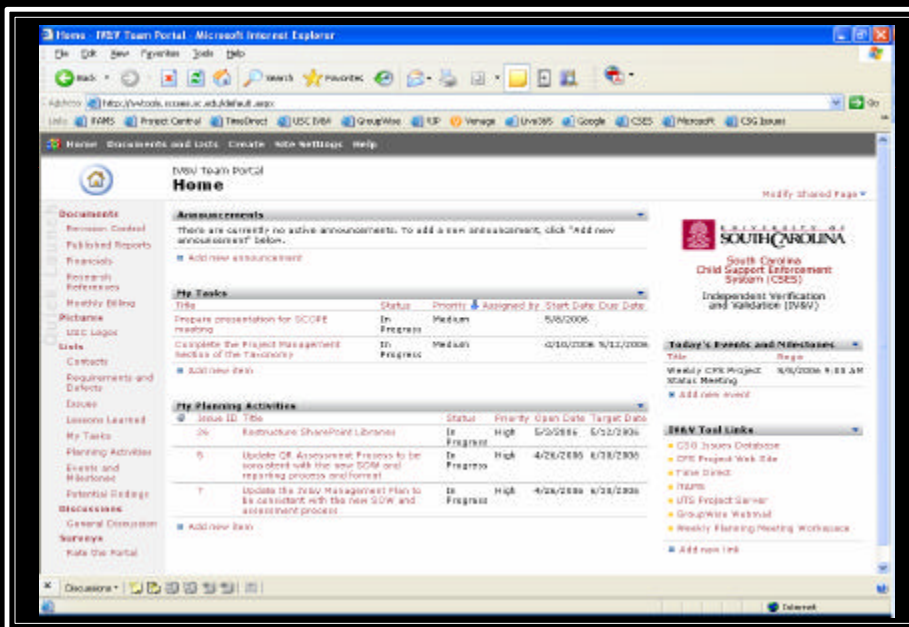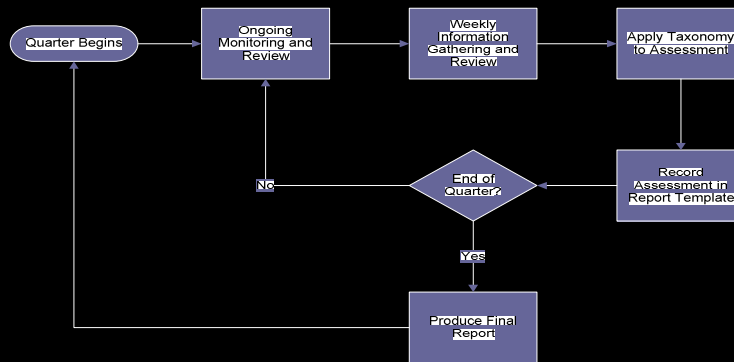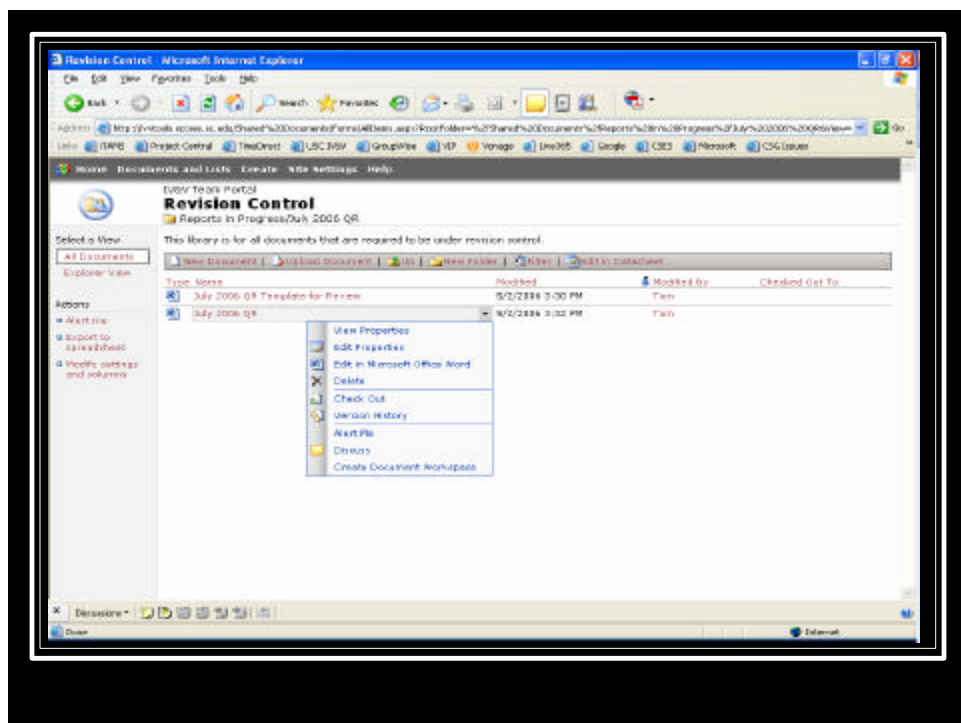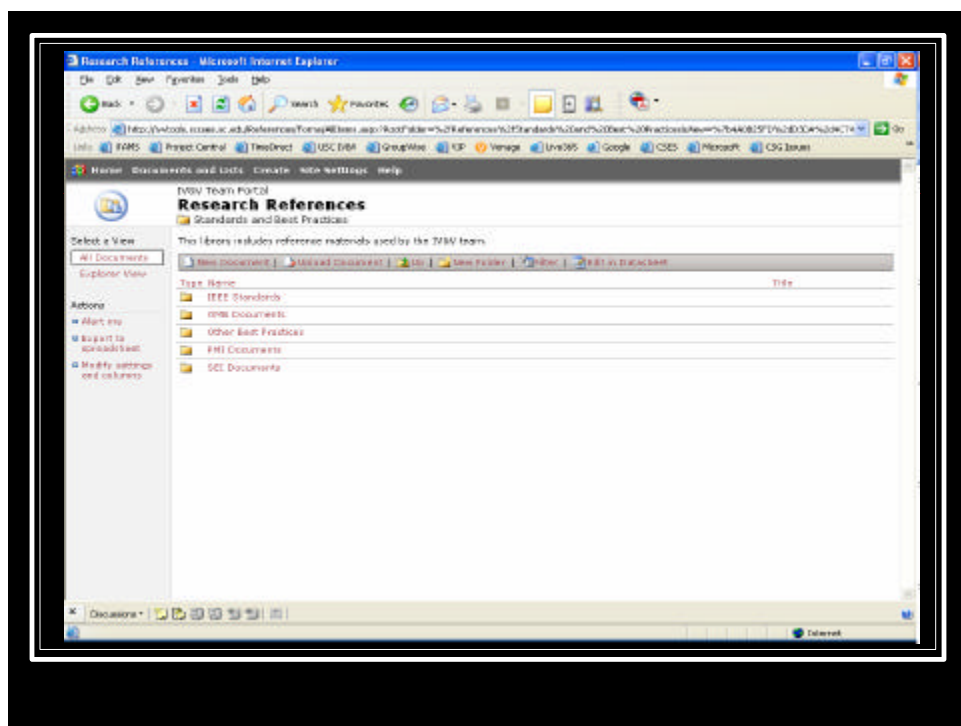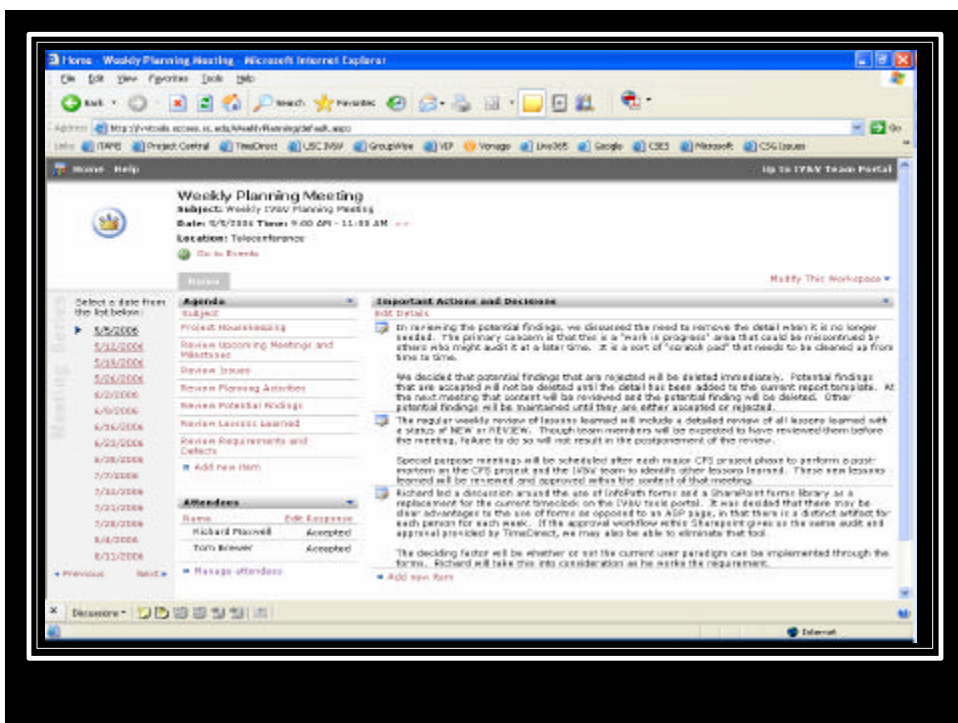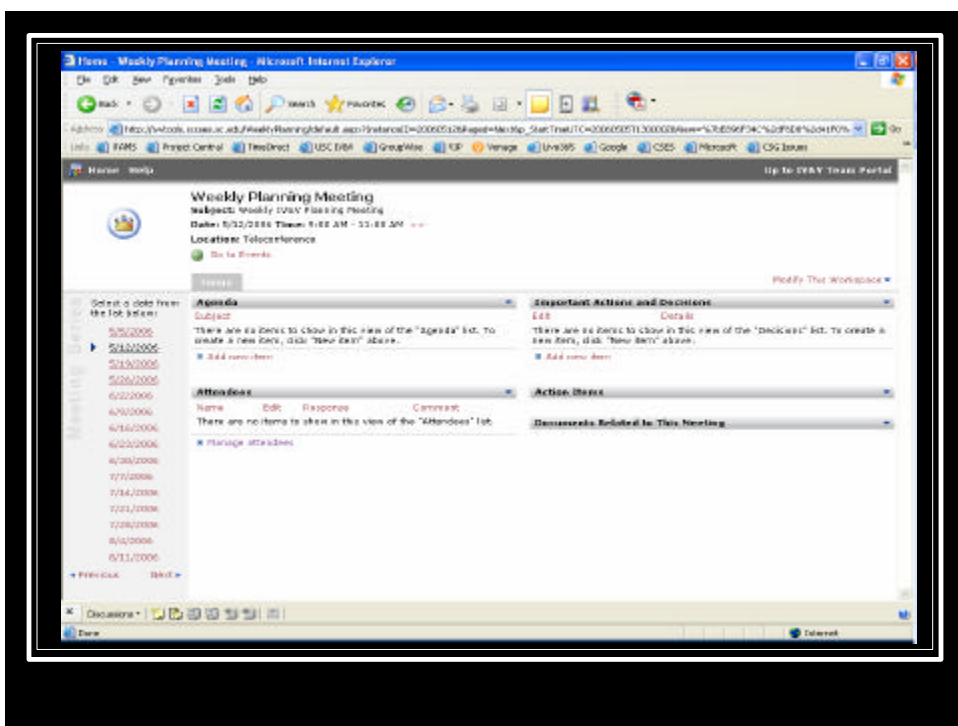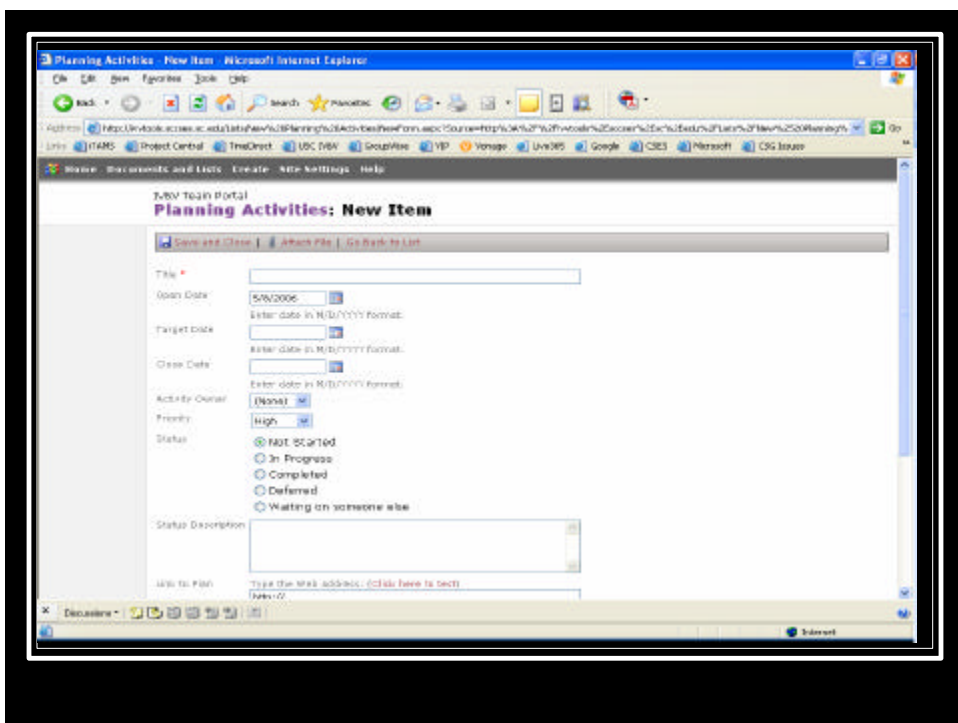
Summary Recommendation

- Verification and Validation is an important part of <u>every</u> IT project
- Assess the scope of V&V and the degree of independence required
- Use IEEE Std. 1012-2004 as a reference to determine what should be required
- Develop a V&V plan in conjuction within the context of the QA plan, or require a separate plan of the IV&V provider
- Execute the plan in parallel with the development life cycle

Questions?????